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NOTES ON THE ANATOMY OF *OREOHELIX*, WITH A CATALOGUE OF  
THE SPECIES.

BY HENRY A. PILSBRY.

The present study is based chiefly upon material collected by Messrs. Junius Henderson and L. E. Daniels in Utah and southern Idaho.<sup>1</sup> Its object is to determine the characters of the reproductive organs and teeth of the species of this area, both as an aid in the discrimination of the species, and to afford a basis for comparison in further work on the genus. The new catalogue of the species and minor forms of *Oreohelix* appended, embodies the results of study in the museum and field from time to time during the past ten or fifteen years.<sup>2</sup>

The genus *Oreohelix* is one of the most difficult groups of land snails within our boundaries by reason of the multiplicity of forms, and the strange parallelism of shell characters sometimes existing between species or races not directly related. This has led to erroneous identifications, with consequent errors in the data of geographic distribution.

The shell seems to be especially plastic; not only are there many local races of various grades of differentiation, but in any colony of some of the species one finds a wide range of variation in the features usually depended on for specific discrimination, such as absolute size, height of the spire, width of the umbilicus relative to the diameter, and development of the sculpture. Sometimes colored and white individuals exist in the same colony. If the banded pattern is primitive in the *strigosa* and *cooperi* groups, as seems highly probable, then it appears that bandless or white mutations have arisen independently in many colonies, where they sometimes exist with the earlier pattern, apparently in hybrid populations.

Eighty-six names have been proposed for forms of all grades; many of these are quite insufficiently defined, and no doubt part

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<sup>1</sup> For data relating to the localities and shells collected reference must be made to their paper "Hunting Mollusca in Utah and Idaho." A few species collected by Mr. Jas. H. Ferriss and the author are also considered.

<sup>2</sup> The writer has personally collected ten of the twenty-four species known. All of the species and subspecies are contained in the collection of the Academy except the following: *O. bruneri* Ancey, *O. cooperi stantoni* Dall, and *O. strigosa imitatoris* Dawson.

of them are superfluous, either because they are synonymous with other names, or because they denote variations not of racial value. In many cases, further collections are requisite, as the small, assorted series of the earlier collectors give no adequate idea of the association of forms in the colonies. Moreover, the location of colonies has often been carelessly recorded, entailing much strenuous field work on the investigator of to-day, work which could have been saved by carefully noting the locations of type localities.

#### DISTRIBUTION OF OREOHELIX.

The genus is almost confined to the western mountain region of the United States, but there is one species in southern Assiniboia and one near the southern boundary of Alberta. Formerly one species extended eastward to eastern Iowa. Southward the genus practically reaches the Mexican boundary, in the Big Hachet mountains of New Mexico and the Huachucas of Arizona; and it will probably be found below the boundary. An outlying species on Catalina Island, California, is widely remote from its kindred, among alien associates.

A northern and a southern area of speciation may be distinguished. The southern group occupies the southern half of New Mexico, Arizona south of the Colorado River, and Catalina Island, California. It comprises all of the recent species of the subgenus *Radiocentrum*, and the species of *Oreohelix* proper which have swollen penes. Species as follows:

<i>O. concentrata.</i>	(RADIOCENTRUM.)
<i>O. metcalfei.</i>	<i>O. avalonensis.</i>
<i>O. pilsbryi.</i>	<i>O. chiricahuana.</i>
<i>O. yavapai.</i>	<i>O. clappi.</i>
<i>O. barbata.</i>	<i>O. ferrissi.</i>
<i>O. socorroensis.</i>	<i>O. hachetana.</i>
<i>O. cooperi.</i>	

Several of these species have one or more subspecies. *O. cooperi* occurs only at considerable elevations, and in forms differing somewhat from northern specimens. *O. yavapai* has been found also in northwestern Wyoming. It is one of the widely distributed species. The other species are special to the southern area.

In the Florida and Dragoon mountains a few imperfect and very old specimens have been recorded doubtfully as *O. strigosa*; but it seems more likely that they belong to the group with swollen penes, some of which resemble *O. strigosa*.

The northern group occupies Arizona north of the Colorado and

northern New Mexico, north to British America, and in its greatest amplitude from the Mississippi River (pleistocene) to eastern Washington. The most widely spread species is *O. cooperi*, with *O. strigosa depressa* next. *O. haydeni* also is spread over a considerable though much smaller area. Most of the other species and races are relatively local in distribution, and many are known from but one or a few contiguous colonies.

*Oreohelix cooperi* still occurs from the Black Hills to Montana and Idaho, and from Assiniboia to the southern third of New Mexico and Arizona. Its range was formerly wider, as it is not uncommon in the loess of eastern Iowa. Its presence there indicates a drier and cooler summer climate than that of eastern Iowa to-day. Where I have collected *O. cooperi* in the mountain states it is a shell of the "aspen zone."

*Oreohelix* is rarely if ever found in abundance except where the country rock is limestone. Some species, in areas largely blanketed by later igneous rock, seem to be wholly restricted to the limestone outcrops. They live on the surface, in dry weather finding refuge under superficial stones, leaves or sticks. Except *O. barbata* in the Chiricahua mountains, I do not remember ever finding *Oreohelix* below the surface layer of stones or rocks.

#### REPRODUCTIVE ORGANS OF OREOHELIX.

The genitalia have a general resemblance to the same organs in *Ashmunella* and *Sonorella*, but there are some differences. There is never a flagellum, though the epiphallus is well developed. The penis-papilla is obsolete or wanting. The penis consists of a lower segment which is longitudinally ribbed within, and an upper segment with thinner walls which are densely papillose within, and enclose a larger cavity. The internally ribbed part is very short in *Radio-centrum*, but from about a third to over half the total length in *Oreohelix* proper. The distal end is truncate or quite shortly bicornute.

In the figures, the organs are shown in nearly their natural positions, except that in some cases the folds of the penis are slightly opened out, to bring the epiphallus into full view. The specific characters are largely a matter of measurements of the epiphallus and penis and its parts. These measurements are taken with dividers after pulling the organs straight, but without stretching. Thus Pl. 20, fig. 1a, and Pl. 22, fig. 7a show the penes of two species pinned out for measuring, after drawing figures in the natural positions.

All figures were drawn with an Abbe camera lucida.

In these PROCEEDINGS for 1905, p. 271, a grouping of the species of *Oreohelix* according to the characters of the genitalia was tentatively advanced. The examination of many more species and local races in the main confirms the arrangement then proposed. By the genitalia the species group as follows.

1. Epiphallus about as long as the penis, the retractor muscle inserted upon it; internally plicate part of the penis very short; animal oviparous, etc. Subgenus *Radiocentrum*.
2. Epiphallus much shorter than the penis, the retractor muscle inserted upon both at their junction (except in *O. barbata*); internally plicate part of the penis  $\frac{1}{4}$  to over  $\frac{1}{2}$  of its length; viviparous species. Subgenus *Oreohelix*.
  - a. Penis long, the distal part about equal in diameter to the lower part, though usually collapsing on account of the thinner walls. *O. strigosa*, *peripherica*, *hendersoni*, *elrodi*, *haydeni* and their varieties. Also *O. cooperi*, which is somewhat intermediate between groups *a* and *b*, being a generalized species in genitalia.
  - b. Penis short, the basal part decidedly more swollen than the distal, *O. yavapai*, *concentrica*, *metcalfei*, *pilsbryi*, *barbata*, and their varieties.

The division of *Oreohelix* into "transversely ribbed," "smooth or striate," and "longitudinally ribbed" groups by Hemphill and Binney is a division of convenience in the identification of specimens, but it has no relation to the affinities of the species.

#### TEETH OF OREOHELIX.

In *Oreohelix* there are two types of teeth, as W. G. Binney first pointed out. In one group the central and inner lateral teeth have no side-cusps or cutting points. Here belong:

- O. strigosa* (Gld.). Binney, T. M. vol. V, Pl. IV, fig. H.<sup>3</sup>  
*O. cooperi* (W. G. B.). Binney, T. M. vol. V, Pl. IV, fig. G, and several examined by myself.  
*O. haydeni* (Gabb). Binney, T. M. vol. V, Pl. XVI, fig. B. Also *O. h. betheli* and *O. h. corrugata* examined by myself.  
*O. peripherica* (Anc.). Binney, T. M. vol. V, Pl. XVI, fig. A (var. *newcombi*). Also numerous radulae of several forms examined by me, from Henderson and Daniel's Stations 29, 30, 33, 36.

<sup>3</sup> Just what race of *strigosa* Binney had remains in doubt. In the same volume he described and figured the genitalia of a Salmon River *strigosa*, which would presumably be *O. s. jugalis*, but perhaps *O. s. subcarinata*. He gives the formula 50-1-50 for a transverse row of teeth. As all the other species of *Oreohelix* examined by Binney and the writer have between 20-1-20 and 33-1-33 teeth, this count is remarkable, and if confirmed would certainly indicate a species distinct from any other of which the dentition is known.

- O. strigosa depressa* (Ckll.). Pilsbry, Proc. A. N. S. Phila. 1905, Pl. XXII, figs. 1-3 (Pecos, N. M.); also from Colorado Springs, near McCammon, Idaho, and Ogden Canyon, Utah.
- O. rugosa* (Hemph.). See fig. 1a. Formula 19, 13, 1, 13, 19.
- O. metcalfei* (Ckll.). Formula 17, 11, 1, 11, 17.
- O. concentrata* (Dall). Pilsbry, Proc. A. N. S. Phila., 1905, p. 276 (Form *huachucana*).
- O. yavapai* (Pils.). Pilsbry, Proc. A. N. S. Phila., 1905, Pl. XXII, fig. 7.

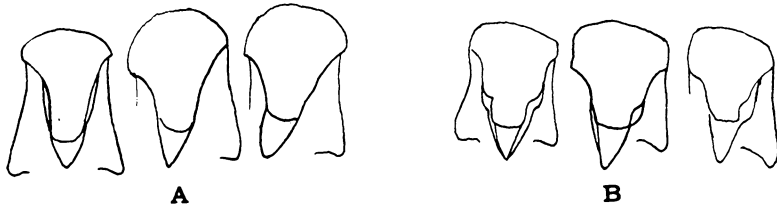


Fig. 1.—Central and two inner lateral teeth of (a) *Oreohelix rugosa*, and (b) *O. hendersoni*.

In the second group the central and all lateral and marginal teeth have side-cusps. Of this kind are:

- O. idahoensis* (Newc.). Binney, T. M. vol. V, Pl. IV, fig. 1.
- O. hemphilli* (Newc.).<sup>4</sup> Binney, T. M. vol. V, Pl. IV, fig. j.
- O. barbata* Pils., Pilsbry, Proc. A. N. S. Phila., 1905, Pl. XXII, fig. 6.
- O. chiricahuana* Pils., Pilsbry, Proc. A. N. S. Phila., 1905, Pl. XXII, figs. 10, 11.
- O. clappi* Ferriss, Pilsbry, Proc. A. N. S. Phila., 1905, Pl. XXII, fig. 4.

In *O. clappi* the cusps and cutting points on the central teeth are very small. In *O. hendersoni* (fig. 1b) they are small and partly united with the lateral cutting edges of the middle cusp. This species is transitional to the form of teeth found in *O. cooperi*, *O. haydeni* and others. There is therefore no hard and fast line of demarcation between the two groups, although nearly all of the species examined are seen at once to belong to one or the other, and the form of the teeth is therefore a useful specific character.

Nearly all of the radulae examined have 29 to 33 teeth on each side of the central tooth. A few have not so many, *O. yavapai* having 26, *O. barbata* 23, and *O. hemphilli*, according to Binney, 20.

<sup>4</sup> Binney reported *O. hemphilli* from "Manitou, Williams Canyon, Colorado." The shell from this place needs comparison with the type of *hemphilli*. Whether his figure of the teeth was from the Nevada or the Colorado form is not known. Fig. 157, Man. Amer. Land Shells, p. 168, is not very characteristic, and if *hemphilli*, it is an immature individual. The type of *O. hemphilli* is No. 23,060 A. N. S. P.

The count of teeth is rather small for a Helicid genus. Mr. Binney's count for "*O. strigosa*," 50-1-50, is so detached from other known species that it needs confirmation.

***Oreohelix strigosa*** (Gld.).

The anatomy of typical *O. strigosa* is unknown, since we have yet to rediscover the typical form. Hemphill's var. *parma* from Spokane Falls is near the original *strigosa*, but it is larger and more solid. Further west, at Blue Lake in the Grand Coulee, there is a small, thin race, closely resembling *jugalis* Hemph. Nothing is known of the soft anatomy of any of the subspecies or races of Washington, central and northern Idaho and Montana.

***Oreohelix strigosa depressa*** (Ckll.). Pl. 19, figs. 1, 2, 3, 4, 6, 7; pl. 120, fig. 8.

(a) Specimens from Manitou Canyon, near Colorado Springs, are taken to be typical *depressa* (fig. 1). The penis is long, from over three-fourths to more than the diameter of the shell, the internally costate portion is not swollen, and is *less than half* the entire length—usually about one-third. It has 5 or 6 ribs inside. The distal portion collapses along three lines, so that its section is trefoil shaped. This is due to three bands where the wall is slightly thicker. It lies coiled in the body, usually showing two principal bends. The general appearance in different individuals is shown in pl. 19, figures 1, 2 (also pl. 19, fig. 5, *O. s. fragilis*.) The form *carnea* (pl. 19, fig. 3) is identical with *depressa* anatomically.

(b) In another series of specimens dissected the distal part of the penis collapses along two instead of three sides, so that its section becomes flattened instead of triangular. It is also less coiled or twisted than in typical *depressa*. This form of penis is shown in pl. 19, figs. 4 and 7, and pl. 20, fig. 8. The last five measurements in the table on page 346 belong to these. While the trefoil and the flat forms are almost always readily distinguishable, yet in a few specimens of the flat type I have opened, there is some indication of a third ridge in part of the length (Stations 43, 46, figs. 3 and 6 of plate 19).

The flat type is probably more primitive than the trefoil, since it is common to this form of *strigosa*, *peripherica* and *haydeni*.

*O. s. depressa* form *tooeleensis* H. and D. (pl. 21, fig. 5), from Station 10, about 6 miles from Tooele, Utah, agrees with many specimens of *depressa* in genitalia. The distal part of the penis is flattened.

The radula of *O. s. depressa* from Colorado Springs has 16, 17, 1, 17, 16 teeth, the central and 5 or 6 inner laterals unicuspid.

*Oreohelix strigosa fragilis* (Hemph.). Pl. 19, fig. 5.

Genitalia as in *O. s. depressa*, the distal portion of the penis collapsing into a trefoil shape in the individual dissected (Station 38).

Length of penis 18 mm.; of internally costate part 5 mm.; epiphallus 4; penial retractor 6 mm.; diameter of the shell about 19 mm.

*Oreohelix strigosa buttoni* (Hemph.). Pl. 21, fig. 6.

Genitalia as in form *tooelensis*, *O. s. depressa* from Provo, and others, the penis collapsing flat. The lower part has 5 ribs within. Length of penis 25 mm., of internally costate portion 10, of epiphallus 7 mm., penial retractor 15 mm.; vagina 6.7 mm. The specimens came from Station 16, Taylor Canyon, near Ogden, Utah.

*Measurements, in mm., of the genitalia of Oreohelix strigosa depressa.*

Locality.	Length of penis.	Length of costate part of penis.	Length of epiphallus.	Length of penial retractor muscle.	Length of vagina.	Length of spermatheca and duct.	Approximate diameter of shell.	Plate 19.
Colorado Springs, Manitou Canyon.....	18.5	6.5	7.5	11	8	....	23	Fig. 1
Near Salt Lake City, Sta. 43.....	24	8	6	11	6	25	.....	Fig. 3
Emigration Canyon, Sta. 46.....	26.5	11	7	7.5	6.5	....	25	Fig. 6
Near McCammon, Idaho, Sta. 2.....	23.5	7	6.3	10	5.5	....	27	Fig. 2
	28	8.5	7	10.5	.....	....	21.5	....
Ogden Canyon, Utah, Sta. 22.....	27.5	9	7	15	6	....	26	Fig. 7
Near Logan, Utah, Sta. 41.....	19.5	5.8	5	9	.....	22	19	Fig. 4
Form <i>tooelensis</i> , Station 10.....	17	7	5	7.5	3.6	....	22	Pl. 21 Fig. 5
Oquirrh Mts., Station 13.....	23	8	7	13.5	6.6	22	25	Pl. 21 Fig. 7
Provo, Utah, Station 44.....	20.5	8.5	7.5	7	6.5	....	23	Pl. 20 Fig. 8

*Oreohelix hendersoni* Pils. Pl. 20, fig. 7.

The length of the penis is three-fourths of the diameter of the shell. Its internally costate segment is one-third the total length, and the distal papillose portion is somewhat flattened. Length of the epiphallus is contained  $2\frac{2}{3}$  times in that of the penis. The penial retractor muscle is shorter than usual in *P. strigosa depressa*.



The lower third of the spermatheca duct is large, then abruptly contracting. There is a general similarity with the genitalia of *O. s. depressa*. Measurements in mm. follow. Length of penis 12, of its costate lower portion 4; epiphallus 4.5; penial retractor 4; vagina 4; spermatheca and duct 10.5; diam. of shell 16 mm.

The three areas of the radula appear distinct, in a slightly enlarged view, the rows of marginal teeth being oblique. In most *Oreohelices* the areas are not well marked. The central tooth and laterals have rudimentary side cusps. Formula 16, 12, 1, 12, 16. Text fig. 1b. By the forms of the individual teeth and the more distinct differentiation of areas in the radula, this species differs from the *strigosa* series.

**Oreohelix haydeni** (Gabb). Pl. 21, figs. 1, 2, 4, 8.

*O. haydeni* does not differ from *O. strigosa depressa* in any important or diagnostic characters of the genitalia or dentition, but the features of the shell seem quite sufficient to give it specific rank.

The typical form, from Weber Canyon in the Wasatch Range, has not been collected alive so far as I know. The forms examined agree pretty closely in soft anatomy. The internally costate part of the penis is about one-third of the total length. The distal portion collapses flat. The penial retractor is decidedly shorter in subsp. *corrugata* and *hybrida* than in subsp. *betheli* and *gabbiana*. This is probably not a character of much importance. The retractor is sometimes continued in the lung floor for some distance, as in pl. 21, figs. 2 and 8. Only the free part is measured in the table. In *hybrida* the penis is more twisted than in the other forms, at least in the individual dissected. In all the forms, the distal part of the penis collapses more or less flat. *O. h. betheli* has four unequal ribs in the lower part.

	Length of penis.	Length of costate part of penis.	Length of epiphallus.	Length of penial retrac- tor muscle.	Length of vagina.	Length of spermatheca and duct.	Approximate diameter of shell.	Plate 21.
<i>O. h. betheli</i> .....	19	6	18+	7.5	21	.....	5	Fig. 2
<i>O. h. gabbiana</i> .....	16	6	11	5.5	.....	.....	5.5	Fig. 1
<i>O. h. corrugata</i> .....	16.5	5	7	5	17	.....	5	Fig. 4
<i>O. h. hybrida</i> .....	16	4	5	4	15	.....	5	Fig. 8

In *O. h. betheli* and *O. h. corrugata* the central and inner lateral teeth are unicuspid, but there are narrow, cutting edges overhanging from the central cusps, in place of side cusps.

***Oreohelix haydeni mixta* n. subsp.**

The shell is whitish with the early whorls clay color (the last whorl sometimes having two narrow brown bands, the upper one ascending the spire). Sculpture often equal, rather fine, deeply cut growth-wrinkles, cut by spiral engraved lines, unequally developed, and on the base often grouped so as to leave spiral bands of long granules at intervals. Periphery angular or subangular in front, becoming rounded on the rest of the last whorl. Embryonic shell having irregular radial ripples, and the usual very fine spiral striation; on the last whorl some coarse spirals; peripheral carina strongly pinched out.

Height 18.3, diam. 12 mm.; umbilicus 3.6 mm.

The genitalia (pl. 21, fig. 3) resemble the organs of *O. haydeni* in proportions, the internally ribbed part of the penis being less than half of the total length, but thicker than in *haydeni*, perhaps an individual feature. The distal part has a somewhat trefoil section. It differs from *O. cooperi* by the longer penis relative to the diameter of the shell, its length being about equal to the diameter in this form, but decidedly less in all of the *cooperi* I have measured. The internally costate part is relatively shorter than in *cooperi*.

Glenwood Springs, Colorado, on the bluff above the Hotel Colorado, among oak leaves and debris on a sandstone and shale ledge above station of *O. h. betheli*. Type No. 94,058 A. N. S. P. (from No. 447 of Prof. Ellsworth Bethel, 1907).

Another lot from Mr. Bethel, No. 94,796, consists of individuals like the above lot, with others having two narrow spiral lines in the usual *cooperi* positions. One of this lot (whether banded or plain not known) was dissected, pl. 22, fig. 5. It agrees with the type in proportions of the penis, but the penial retractor and the vagina are shorter. Measurements of the genitalia in mm. follow.

Mus. No.	Length of penis.	Length of internally ribbed part of penis.	Length of epiphallus.	Length of penial retractor.	Length of vagina.	Diameter of shell.
94,058....	18	6.8	6.3	18	9	18.3
94,796....	17.5	7.7	6	8	6	about 18

This is the form which was at one time identified as *O. haydeni gabbiana*. It resembles *O. h. hybrida* very closely, but the embryonic stage differs. The last embryonic whorl is not so convex in *mixta*, and its major spirals are more distinct and the radial ripples are more irregular. The carina is decidedly more prominent, and the whorl as a whole is distinctly more depressed. It is likely that *hybrida* and *mixta* are independent forms of the *haydeni* stock, or perhaps separated relics of a pro-haydeni race.

Some specimens have much the appearance of *cooperi*, but the genitalia show that there is no real connection. There is large individual variation in the height of the spire.

The embryonic shell of *O. h. gabbiana* has stronger spirals both above and below near the end of the last embryonic whorl; its periphery is less pinched out, and it is less depressed. The adult *gabbiana* is usually more strongly angular or keeled.

***Oreohelix peripheria* (Ancey).** Pl. 20, figs. 1 to 6.

In genitalia this species does not differ materially from *O. strigosa depressa* (b) and *O. haydeni*. The internally costate part of the penis is less than half of the total length, usually slightly over a third. The internally papillose distal portion usually collapses flat, but one specimen from Station 30 and one from 36 there are weak indications of a third ridge. The cylindric lower part of the penis has 5 or 6 longitudinal ribs within.

Many specimens were opened, from various localities, and including nearly smooth, fine-ribbed and coarse-ribbed, white and banded individuals. Except in size, there is very little variation.

*Measurements, in mm., of the genitalia of Oreohelix peripheria.*

Locality.	Length of penis.	Length of costate part of penis.	Length of epiphallus.	Length of penial retractor.	Length of vagina.	Length of spermatheca and duct.	Approximate diameter of shell.	Plate 20.
Station 26.....	18.5	6	4	.....	.....	.....	18-20	Fig. 4
Station 26.....	16	6	5.5	8.5	.....	.....	.....	.....
Station 29.....	18.5	7.2	6	.....	5.5	18	18-25	Fig. 3
Station 30.....	14	6.5	4	5.5	4.5	.....	.....	Fig. 6
Station 33.....	18	8	4	11.5	6.6	18	195-20	Fig. 2
(White)								
Station 33.....	18	6.5	4.5	10	6	21	20	Fig. 1
(Banded)								
Station 36.....	21	7.5	5	13.5	6.5	23.5	20	Fig. 5

The central and inner lateral teeth have no side cusps. There are about 12 lateral teeth on each side (Station 30). In an individual from Station 36 there are 17, 13, 1, 13, 17 teeth. The transition from lateral to marginal teeth is very gradual in this species, so that the exact number of laterals is somewhat uncertain.

**Oreohelix rugosa** (Hemphill). Pl. 22, figs. 7, 7a.

The penis is about two-thirds the diameter of the shell, therefore shorter than in any form of *O. s. depressa* examined. Its internally costate lower portion is relatively decidedly longer than in *O. s. depressa*, being over half the total length, agreeing with that of *O. cooperi*. Inside the lower part has 5 or 6 fleshy ribs, smooth, as usual, and the upper part has about the same number, but they are lower, and both ribs and intervals are papillose. The duct of the spermatheca is longer than in *O. s. depressa*. Two individuals measure:

Length of penis.	Length of costate part of penis.	Length of epiphallus	Length of penial retractor.	Length of vagina.	Length of spermatheca and duct.	Diameter of shell.
16	11	6	.....	6	29	24.5
16	10	6.2	7.6	.....	.....	.....

There are about 13 lateral teeth on each side, the inner 9 to 11 without side cusps. The transition to marginals is very gradual.

**Oreohelix cooperi** (W. G. B.). Pl. 22, figs. 1, 2, 3, 4.

Specimens from Wyoming, Utah, Colorado and New Mexico have been dissected. All agree in having the internally costate part of the penis longer than the papillose part, which at once differentiates the species from *O. strigosa* and *O. peripherica*, in which the costate part is much shorter than the papillose part. The penial retractor is short, less than half the length of the penis in the smaller specimens, but about two-thirds the length of penis in the large forms from Yellowstone Park and New Mexico. The median part of the penis is often somewhat swollen, but in other examples this is not noticeable.

The penis has usually four main fleshy ridges in the lower part as in specimens from McCammon, Idaho (fig. 2), and the Black Range of New Mexico, or there may be about 6 unequal ridges (fig. 1, Yellowstone Park, No. 96,973), one of them continuing upwards

further than the others. In the Black Range form the ribbed portion projects upwards into the cavity of the papillose part.

*Measurements in mm., of the genitalia of Oreohelix cooperi.*

Locality.	Length of penis.	Length of costate part of penis.	Length of epiphallus.	Length of penial retractor.	Length of vagina.	Length of spermatheca and duct.	Approximate diameter of shell.	Plate.
Gleneyre, Colo., 7,000 ft. 82,185.....	8.6	4.6	4.3	2.4	2	11	16-18	Fig. 3
McCammon, Idaho, Station 1.....	12	7.5	5.5	5.3	3.7	21	22	Fig. 2
Eureka, Utah, Station 6.....	12	6.5	5	4	3.7	.....	15-16	Fig. 4
<i>O. cooperi maxima</i> . Yellowstone Park, 96,973.....	14.5	8.7	5	10	5	24	26	Fig. 1
Black Range, N. M. Sta. 26.....	15.5	9	5	9	5	.....	.....	.....

*Oreohelix yavapai extremitatis* Pils. & Ferr. Pl. 22, figs. 6, 6a.

The specimen figured is from Shell, Wyoming (Pilsbry, Nautilus XXVII, 1913, p. 50). The penis is short, its lower two-thirds swollen, upper third cylindric; internally there are very low, short folds bounded above by a low narrow transverse ridge, in the enlarged part, the upper part having densely papillose walls. Fig. 6a represents the penis opened and pinned flat. The papillæ in the upper portion are represented diagrammatically. The epiphallus is not quite half as long as the penis. The base of the spermatheca duct is enlarged, as usual. The uterus contained 8 embryos in the individual figured, the largest of  $2\frac{1}{3}$  whorls. Length of penis 7 mm., of its internally costate part 4.5; epiphallus 3.3 mm.; vagina 2 mm.; spermatheca and duct 13 mm.

The central and 5 or 6 inner lateral teeth have no side cusps. The seventh lateral has a well developed ectocone.

The jaw is striate as usual in the genus.

The animal is purplish black above and on the sides, the sole cream colored.

The embryonic shell has  $2\frac{1}{3}$  whorls, is convex above with an angular, not acute, periphery. The first  $1\frac{1}{2}$  whorls are convex with irregular growth striæ, some microscopic spirals then appearing. The last third of a whorl has about 5 coarse but very low spirals, and the

cuticle, under a high power, is seen to be minutely crinkled, also on the base.

**Oreohelix concentrata** (Dall). Pl. 22, fig. 9.

The specimen figured is No. 94,343 A. N. S. P., from Miller's Peak, Huachuca Mts., Arizona. The penis is swollen below the middle, length 8 mm., length of internally costate part 4.5 mm.; of epiphallus 4 mm.; of vagina about 3.6 mm. Diameter of the shell 15.5 mm.

This agrees substantially with the large form of the same district, *O. c.* form *huachucana* (Pilsbry, Proc. A. N. S. Phila. 1905, p. 275, pl. 19, fig. 6). Both differ from *O. strigosa* by the swollen penis and relatively larger costate portion, which occupies more than half the total length, as in *O. cooperi*. My former reference of *concentrata* and *huachucana* to *O. strigosa* as subspecies was clearly erroneous, and due to the fact that I had not dissected enough *Oreohelices* to appreciate their specific characters. In the general discussion of the anatomy (Proc. A. N. S. Phila. 1905, p. 271), *O. strigosa* and *huachucana* were put in separate divisions.

**Oreohelix metcalfei** Ckll. Pl. 22, fig. 10.

Collected in abundance by Mr. Ferriss and the writer, in the Black Range, New Mexico. The penis resembles that of *O. concentrata* and *O. pilsbryi*, the median portion being much swollen, with very thick walls, and broad, longitudinal ribs inside. The much narrower, twisted upper portion has coarse papillæ within, and one longitudinal papillose rib. Length of penis 12 mm., of its internally costate portion 7 mm.; of epiphallus 4 mm.; vagina 4 mm. Diameter of the shell 19.5 mm.

The radula has 12 lateral teeth on each side, like those of *O. s. depressa* except that the cusps are more slender.

**Oreohelix pilsbryi** Ferriss. Pl. 22, fig. 8.

Genitalia about as in *O. metcalfei*. The swollen part of the penis has about 6 unequal ribs within; these project slightly into the cavity of the papillose portion, which has one longitudinal rib. Length of penis 12, of the ribbed portion 7 mm.; epiphallus 4 mm.; penial retractor 4 mm.; vagina 4 mm.; spermatheca and duct 15 mm. Diameter of the shell 17.6 mm.

Although the shell of *O. pilsbryi* has an astonishing similarity to that of *O. haydeni*, the genitalia show that there is no direct relationship. *O. metcalfei* is closely related to *pilsbryi*, being anatomically indistinguishable.

## CATALOGUE OF SPECIES, SUBSPECIES, AND OTHER NAMED FORMS.

*Note.*—An asterisk (\*) following a specific or varietal name indicates that a figure of the genitalia has been published by the writer, and serves to show what species and subspecies require examination. Several other subspecies of the Arizonian species have been dissected but not figured.

- O. IDAHOENSIS (Newc.). Coeur d'Alene district, Idaho.
- O. COOPERI (W. G. B.).\* Black Hills, S. Dakota; (Rocky Mountains).  
     Forms *trifasciata* Ckll., Mesa Co., Colo.; *confluens* Ckll., Garfield and Mesa Cos., Colo.; *elevata* Ckll., Delta Co., Colo.; *typica* Ckll., Colo.; *minor* Ckll., Routt Co., Colo.; *iowensis* Pils., Loess of Iowa; *maxima* Pils.,\* Yellowstone Park.
- O. c. stantoni Dall. Assiniboia.
- O. c. globosula Ckll. Summit Co., Colo. (Syn. *globulosa* Pils.).
- O. c. berryi Pils. Snowy Mts., Fergus Co., Mont.
- O. RUGOSA (Hemph.).\* Near Brigham City, Utah.
- O. PERIPHERICA (Ancey).\* Bear River region, Northern Utah. (Syn., *multicostata*, Hemph.)  
     Forms *binneyi*, *castanea*, *albofasciata*, *gouldi* Hemph.
- O. p. newcombi (Hemph.). Near Ogden, Utah.
- O. p. wasatchensis (Hemph.). Near Ogden, Utah.
- O. PYGMÆA Pils. Near Shell, Wyoming.
- O. STRIGOSA (Gld.). "Interior of Oregon."  
     O. s. parma (Hemph.). Spokane Falls, Washington.
- O. s. jugalis (Hemph.). Salmon River, Idaho.
- O. s. intersum (Hemph.). Salmon River, Idaho.
- O. s. limitaris (Dawson). Waterton Lake, Montana-Alberta boundary.
- O. s. alpina Elrod. Mission Range, Montana. (Syn.: *montana* Elrod.)
- O. s. subcarinata (Hemph.). Rathdrum, Idaho.  
         Forms *lactea*, *bicolor* and *picta* Hemph. Same colony.
- O. s. depressa (Ckll.).\* Near Durango, Colo.; (Southern Idaho to northern Arizona, Colo., New Mexico).  
         Form *major* Ckll. Mesa Co., Colo.
- " *sinistrorsa* Ckll., Colorado.
- " *carnea* Hemph.\* Near Salt Lake City, Utah.
- " *albida* Hemph. Near Logan, Utah. (? Syn., *Patula strigosa* var. *alba* Ckll., preoc.).
- " *tooelensis* Hend. and Dan.\* Near Tooele, Utah.
- O. s. fragilis (Hemph.).\* Near Franklin, Idaho.
- O. s. buttoni (Hemph.).\* Box Elder Co., Utah; also near Ogden.
- O. s. magnicornu Pils. Big Horn Mts., Wyoming.
- O. HENDERSONI Pils.\* Little Thompson Creek, 10 miles N. W. of Longmont, Colo.
- O. h. dakani Hend. New Castle, Colo. (? = *rugosa* Hemph.).

- O. HAYDENI (Gabb.). Weber canyon, Utah.
  - O. h. oquirrhensis (Hemph.). Oquirrh Mountains, Utah.
  - O. h. gabbiana (Hemph.).\* Oquirrh Mountains, Utah.
  - O. h. utahensis (Hemph.). Oquirrh Mountains, Utah.
  - O. h. corrugata Hend. and Dan.\* Small, nearly isolated mountain, southeast of Webster, Utah.
  - O. h. hybrida (Hemph.).\* Near Logan, Utah.
  - O. h. betheli Pils. and Ckll.\* Glenwood Springs, Colorado.
  - Form *alta* Pils. and Ckll. Glenwood Springs, Colorado.
  - O. h. mixta Pils.\* Glenwood Springs, Colorado.
- O. HEMPHILLI (Newc.). White Pine mining district, Nevada.
  - O. h. eurekaensis Hend. and Dan. Eureka, Utah.
- O. TENUISTRIATA Hend. and Dan. Between McCammon and Hot Lava Springs, Idaho.
- O. CARINIFERA Pils. Garrison, Montana.
- O. BRUNERI (Ancey). Montana. (Not seen by the author, and unknown in American collections.)
- O. ELRODI Pils.\* MacDonald Lake, Mission Range, Montana.
- O. YAVAPAI Pils.\* Yavapai Co., Arizona, etc.
  - O. y. neomexicana Pils.\* San Miguel Co., New Mexico.
  - O. y. compactula Ckll. Pecos canyon, New Mexico.
  - O. y. extremitatis Pils. and Ferr.\* Grand Canyon, Ariz.; also northern Wyoming.
  - O. y. angelica Pils. and Ferr. Grand Canyon, Arizona.
  - O. y. profundorum Pils. and Ferr. Grand Canyon, Arizona.
  - O. y. mariæ Bartsch. Squaw Creek, near mouth Gallatin Canyon, Montana.
- O. CONCENTRATA (Dall).\* Huachuca Range, Arizona.
  - Form huachucana Pils.\* Huachuca Range, Arizona.
- O. METCALFEI Ckll.\* Black Range, New Mexico.
- O. PILSBRYI Ferriss.\* Mineral Creek, Chloride, Sierra Co., New Mexico.
- O. BARBATA Pils.\* Chiricahua Range, Arizona; also Mogollon Range, N. M.
  - O. b. minima Pils. and Ferr. Chiricahua Range, Arizona.
- O. SOCORROENSIS Pils. Socorro Co., New Mexico.
  - Subgenus *Radiocentrum* Pils.
- O. AVALONENSIS Hemph. Catalina Island, California.
- O. CHIRICAHUANA Pils.\* Cave Creek Canyon, near the cave, Chiricahua Range, Arizona.
  - O. c. percarinata Pils. and Ferr. Big Emigrant Canyon, and Paradise Canyon, Chiricahua Range, Arizona.
  - O. c. obsoleta Pils. and Ferr. White Tail Canyon, Chiricahua Range, Arizona.
- O. CLAPPI Ferriss.\* Cave Creek, etc., Chiricahua Range, Arizona.
  - O. c. emigrans Pils. and Ferr. Big Emigrant Canyon, Chiricahuas.
  - O. c. cataracta Pils. and Ferr. Falls of Cave Creek, Chiricahuas.



O. FERRISSI Pils.\* Near mouth of Sheridan Canyon, Big Hachet Mountains, New Mexico.

O. f. morticina Pils. Daniels Peak, Big Hachet Mts., New Mexico.

O. HACHETANA Pils.\* Summit of Big Hachet Mt., New Mexico.

O. h. cadaver Pils. Daniels Peak, Big Hachet Mts., N. M.

#### NOTES ON THE PRECEDING LIST.

In presenting a new catalogue of a genus wherein specific values have been so variously estimated, a brief consideration of the growth and changes of opinion on the subject may be in order. In their work of 1869, Binney and Bland recognized *Helix strigosa*, *H. cooperi* and *H. idahoensis* as species, no others being then known. In 1878 (Terrestrial Mollusks, Vol. 5) Mr. Binney added *H. haydeni* and *H. hemphilli*, and reduced *cooperi* to a variety of *strigosa*. In his latest general work, Manual of American Land Shells, 1885, Mr. Binney reduced *haydeni* to the rank of a variety of *strigosa*. After this, the remarkable series from Idaho and Utah collected by Henry Hemphill caused Binney to view the entire series of known forms as varieties of *strigosa*. This view was generally accepted, as Mr. Binney was conceded to be the leading authority of his time on American land snails. Mr. Hemphill went further than Binney, ranking the whole group as varieties of the Eastern *H. alternata* Say.

It may be noted here that a relatively small number of species, from only a part of the area of the genus, were known to Binney and Hemphill. The last 15 species of the list given above were unknown at that time. This includes the whole southern group of species having swollen penes and the *Radiocentrum* group (with one exception), besides various lately discovered northern forms of very distinct appearance. In dealing with the species and other forms described prior to 1890 we return to Binney's earlier opinion, and regard *strigosa*, *cooperi*, *idahoensis*, *haydeni* and *hemphilli* as species. *O. peripherica* and *O. hendersoni*, while near *strigosa*, seem to be sufficiently detached to be considered species. *O. rugosa*, though near *cooperi*, is for the time given specific rank. Both of these differ specifically from *strigosa* by the genitalia.

Many of the *subspecies* now recognized were already defined by Binney and Hemphill as varieties of *strigosa*. If the criterion of intergradation with other forms were rigorously applied to them, several would be judged species; yet in actual practice, and as a temporary expedient until the territory is more fully explored, we take the degree of differentiation into the account. In dealing with the forms of single colonies, scattered over a great extent of

unexplored country, our present conclusions must be mere approximations to the facts, which future exploration may be expected to bring out. In treating of forms which are in doubt it seems to me better to attach them as subspecies to a known species, rather than to increase the number of ill-defined species. *Oreohelices* sometimes have strongly marked conchological features, but when this is not the case, species should not be established in my opinion, without anatomical examination. It seems likely that some forms now considered subspecies of *O. strigosa* will be elevated to specific rank when their areas are well explored, and their soft anatomy worked out.

The "forms" of the list above are of unequal value, but all are inserted in order that all names proposed may appear in the list. Some of them are mere synonyms; some are color or size forms, from heterogeneous colonies, in which several mutations are perpetuated in hybrid populations,<sup>5</sup> such as I have described in *Achatinella*.<sup>6</sup> Others are races probably deserving recognition in nomenclature. Much more study must be put on *Oreohelix* before we can confidently assign all the forms to their approximately proper rank.

*O. cooperi* (W. G. B.). No serious study of the races and forms of this wide-spread species has recently been made. Many years ago Professor Cockerell proposed several varietal names, but in the absence of figures, the application of some of them, as well as their status, has been uncertain. A recent communication from Professor Cockerell quoted below, elucidates them so far as possible in the present condition of the subject.

- (1) *typica* = *O. cooperi* s. str.
- (2) *confluens*. (3) *trifasciata*. Color (band) variations of *cooperi*, common and well known to us here. Not in any sense special races. Type specimen of *confluens* is in U. S. N. M.
- (4) *elevata*. A form of *cooperi* with more elevated spire. Merely an extreme of the ordinary variation of the species; not a race.
- (5) *minor*. The name was originally given in Nautilus May, 1889, p. 8, and referred to a small form cited by Hemphill. Later I found what I considered to be the same in Colorado, apparently a distinct race. Henderson has used the name for a race in recent years. Now we are both uncertain whether the name should be applied in this sense. It is a fact that in certain localities the shells are small and constitute a "minor" race, but whether all the various colonies of this type have any connection with one another may be questioned. The original intention was to follow the European custom, and call all the shells below a certain size *minor*, not regarding the variety as a race or subspecies in any sense. Henderson and I, after consultation, agree that the status of *minor* must be considered subject to revision.
- (6) *globosula*. This we have, and can recognize it as a peculiar variation which occurs in the Glenwood Springs district. It occurs in small numbers on the south side of the river, along with the other forms. It may be a hybrid of

<sup>5</sup> See the valuable observations of Daniels, Nautilus XXV, 1911, p. 18.

<sup>6</sup> Manual of Conchology, Vol. XXII.

some sort. It does not seem to be a distinct race or subspecies, but it is not found in other parts of the state so far as we know. The type locality is some distance from the Glenwood Springs locality, but a *wide* range does not appear probable. We can affirm, I think, that this is not a mere variation of the ordinary type, such as *confluens*, etc.; but whether it is a distinct race may well be doubted. Further research is needed.

(7) *depressa*. This you know well.

(8) *major*. Simply a large *depressa*; not a race.

(9) *sinistrorsa*. Sinistral examples. (Brit. Naturalist.)

Thus, only two names are at all doubtful, and here the doubt is essentially one as to the facts of nature rather than of nomenclature. (Theo. D. A. Cockerell.)

*O. cooperi* form *maxima* is a shell with about the typical shape of *cooperi*, but of large size, the type measuring, alt. 17.6, diam. 26 mm., umbilicus 5 mm., whorls  $5\frac{1}{2}$ , more rounded than in *O. strigosa depressa*. There is a band at, another above the periphery, and below the suture a wider, paler one interrupted into maculæ. Genitalia, pl. 22, fig. 1, normal for *cooperi*.

The type is from Yellowstone National Park 10 miles southwest of Jardine, Montana, No. 96,973 A. N. S. P., collected by E. M. Kindle. Other specimens are from Grade Canyon near Cokeville, Uinta Co., Wyoming, collected by Mr. J. A. G. Rehn. One of these measures alt. 17.7, diam. 26 mm. In addition to the markings described above, it has a few faint brown circular lines on the base.

Form *iowensis* Pils. is quite small, height 7.7, diam. 11.4, umbilicus 2.6 mm., with  $4\frac{3}{4}$  whorls. There is a reddish band just under the periphery, and the initial whorl is very convex and smooth. It is from the loess, type-locality, Iowa City, Iowa. It probably stands close to *stantoni*, which still exists in an environment perhaps not very unlike the loess climate of Iowa.

*O. p. wasatchensis* is so peculiarly modified that one is strongly inclined to give it specific rank. The elevated spire, the compactly coiled whorls and the peripheral carina all differentiate it from *O. peripherica*. Yet *O. p. newcombi* stands almost intermediate between *wasatchensis* and *peripherica*. It does not differ from the coarsest examples of the latter in form or ribbing, but it has a delicate peripheral keel which continues as far, usually, as the last whorl, whereas *O. peripherica* has no keel in the later neanic and the adult stages. Possibly both *newcombi* and *wasatchensis* may eventually be ranked as species; but until further collections can be made, I leave them associated with *O. peripherica*, with the note that at present we do not have actual evidence of intergradation.

In this connection we may allude to the status of *O. pygmæa*, which may turn out to be a subspecies of *O. peripherica*; yet here again, evidence of intergradation is wanting.

## EXPLANATION OF PLATES XIX, XX, XXI, XXII.

NOTE.—The “stations” referred to are those of Messrs. Henderson and Daniels Expedition of 1915.

PLATE XIX.—Fig. 1.—*Oreohelix strigosa depressa* (Ckll.) Manitou Canyon, Colorado Springs, Colo.

Fig. 2.—*O. s. depressa* (Ckll.) Harkness Canyon, near McCammon, Idaho, Station 2.

Fig. 3.—*O. s. depressa* form *carnea* (Hemph.). Dry Canyon, near Salt Lake City, Utah, Station 43.

Fig. 4.—*O. s. depressa* (Ckll.). First gulch south of Logan Canyon, east of Logan, Utah, Station 41.

Fig. 5.—*O. s. fragilis* (Hemph.). About a mile west of Franklin, Idaho, Station 38. Penis only figured.

Fig. 6.—*O. s. depressa* (Ckll.). About a mile up Emigration Canyon, southeast of Salt Lake City, Utah, Station 46.

Fig. 7.—*O. s. depressa* (Ckll.). Ogden Canyon, Utah, Station 22.

PLATE XX.—Fig. 1.—*Oreohelix peripherica* (Ancey). Ravine in east bluff of Bear River, just below Wheelon, Utah, Station 33, banded form. 1a, penis of same, pulled straight, with epiphallus.

Fig. 2.—*O. peripherica* (Anc.). Same station, white form.

Fig. 3.—*O. peripherica* (Anc.). East bank of Bear River below Cache Junction, Utah, Station 29. 3a, penis of same, opened to show internal structure.

Fig. 4.—*O. peripherica* (Anc.). Gulch opening into North Ogden Canyon, Station 26. A relatively smooth specimen.

Fig. 5.—*O. peripherica* (Anc.). Mountain northeast of Newton, Utah, Station 36. Smooth form of the species.

Fig. 6.—*O. peripherica* (Anc.). East bank of Bear River, below Cache Junction, Utah, Station 30.

Fig. 7.—*Oreohelix hendersoni* Pils., one of the original lot.

Fig. 8.—*Oreohelix strigosa depressa* (Ckll.). Rock Canyon, east of Provo, Utah, Station 44.

PLATE XXI.—Fig. 1.—*Oreohelix haydeni gabbiana* (Hemph.). Oquirrh Mts., Station 15.

Fig. 2.—*Oreohelix haydeni betheli* Pils. and Ckll. Glenwood Springs, Colorado. No. 94,059 A. N. S. P.

Fig. 3.—*O. haydeni mixta* Pils. Glenwood Springs, Colorado. No. 94,058 A. N. S. P.

Fig. 4.—*Oreohelix haydeni corrugata* Hend. and Dan. Small mountain southeast of Webster, Utah, Station 40.

Fig. 5.—*Oreohelix s. depressa*, form *tooeleensis* Hend. and Dan. About 6 miles northeast of Tooele, Utah, Station 10.

Fig. 6.—*Oreohelix strigosa buttoni* (Hemph.). Taylor Canyon, near Ogden, Utah, Station 16.

Fig. 7.—*Oreohelix strigosa depressa* (Ckll.). Oquirrh Mountains, Utah, Station 13.

Fig. 8.—*Oreohelix haydeni hybrida* (Hemph.). Gulch south of Logan Canyon, Station 42.

PLATE XXII.—Fig. 1.—*Oreohelix cooperi* (W. G. B.), form *maxima* Pils. Yellowstone National Park. No. 96,973 A. N. S. P.

Fig. 2.—*O. cooperi* (W. G. B.). McCammon, Idaho, Station 1.

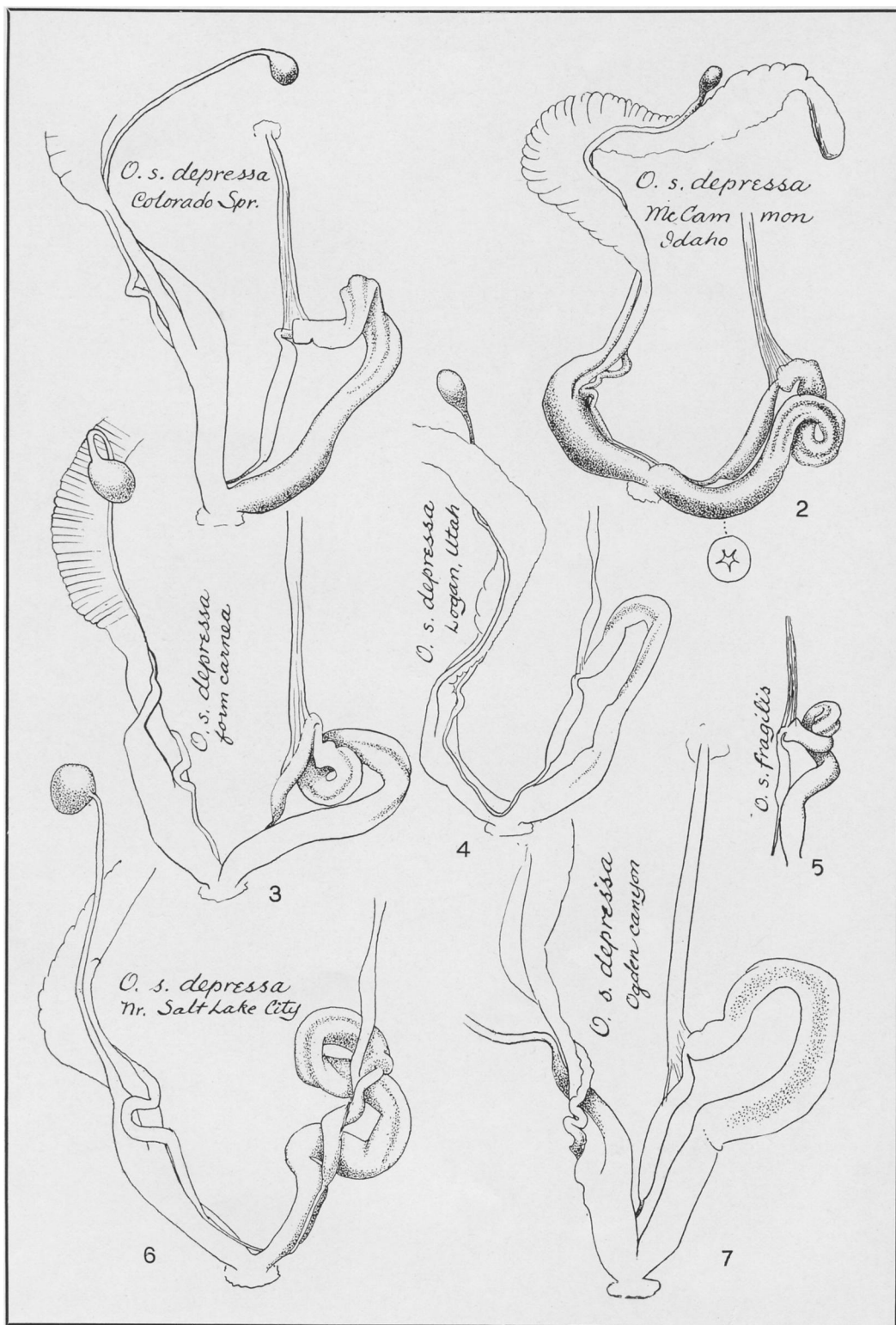
Fig. 3.—*O. cooperi* (W. G. B.). Gleneyre, Colorado. No. 82,185 A. N. S. P.

Fig. 4.—*O. cooperi* (W. G. B.). Eureka, Utah, Station 6.

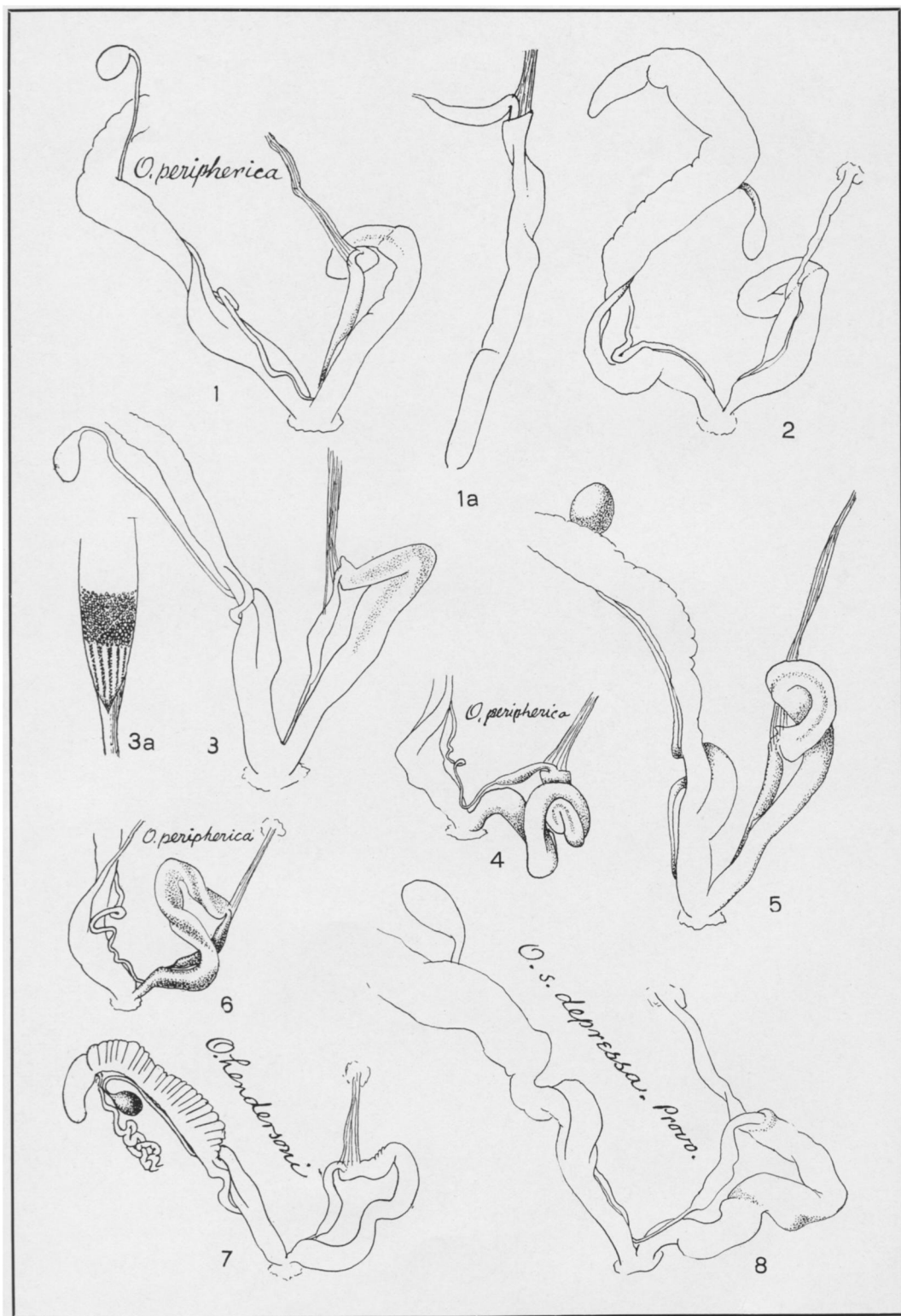
Fig. 5.—*O. haydeni mixta* Pils. Glenwood Springs, Colorado. No. 94,796 A. N. S. P.

Fig. 6.—*Oreohelix yavapai extremitatis* Pils. and Ferr. Shell, Wyoming. 6a, penis of same, opened, with the epiphallus.

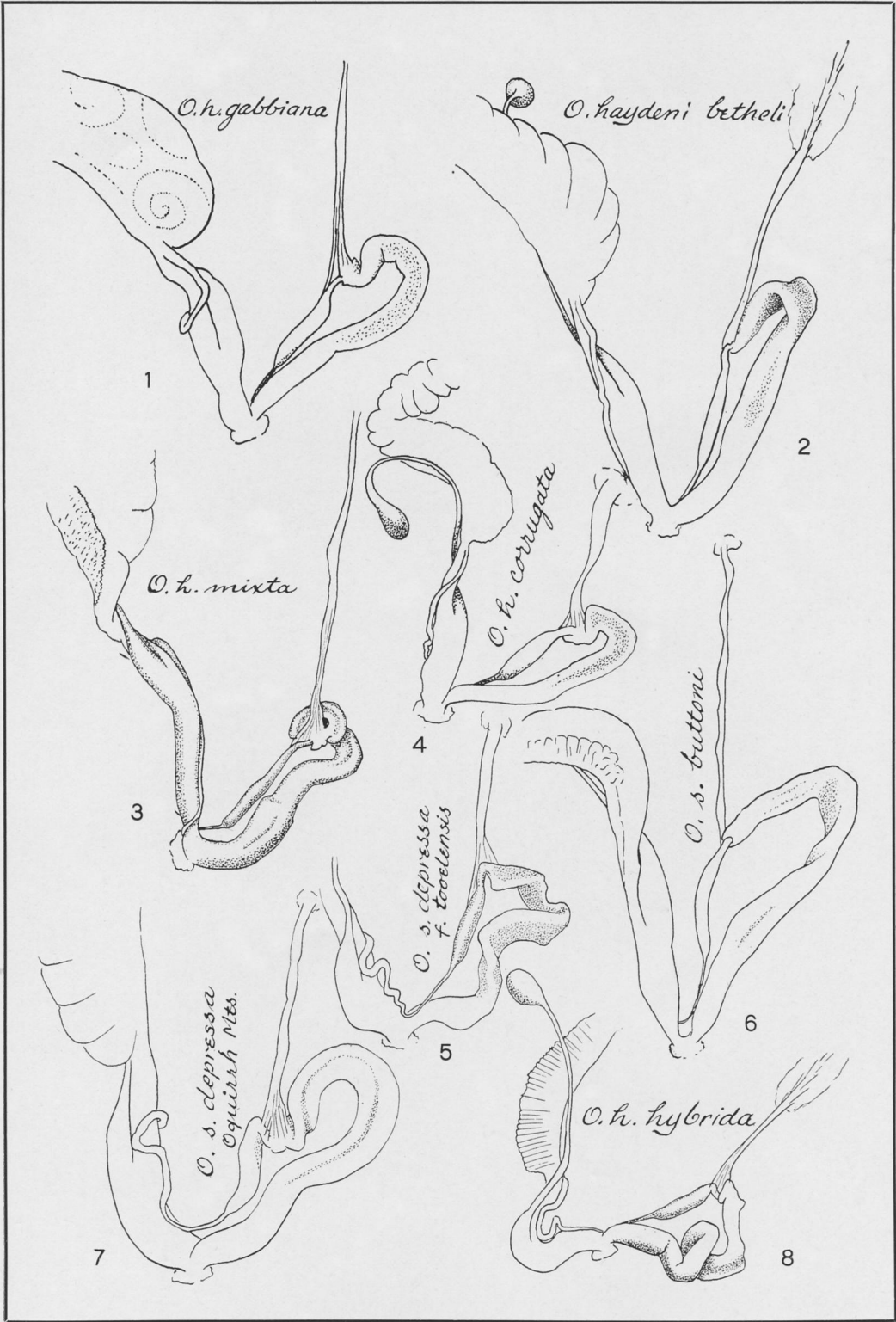
- Fig. 7.—*Oreohelix rugosa* (Hemph.). Near Clarkston, Utah, Station 3.  
7a, penis of same, pulled straight.  
Fig. 8.—*Oreohelix pilsbryi* Ferriss. Type-specimen.  
Fig. 9.—*Oreohelix concentrata* (Dall). Huachuca Mts., Arizona. No. 94,343  
A. N. S. P.  
Fig. 10.—*Oreohelix metcalfei* Ckll. Black Range, New Mexico, Pilsbry  
and Ferriss, Station 15, 1915.



PILSBRY: ANATOMY OF OREOHELIX.

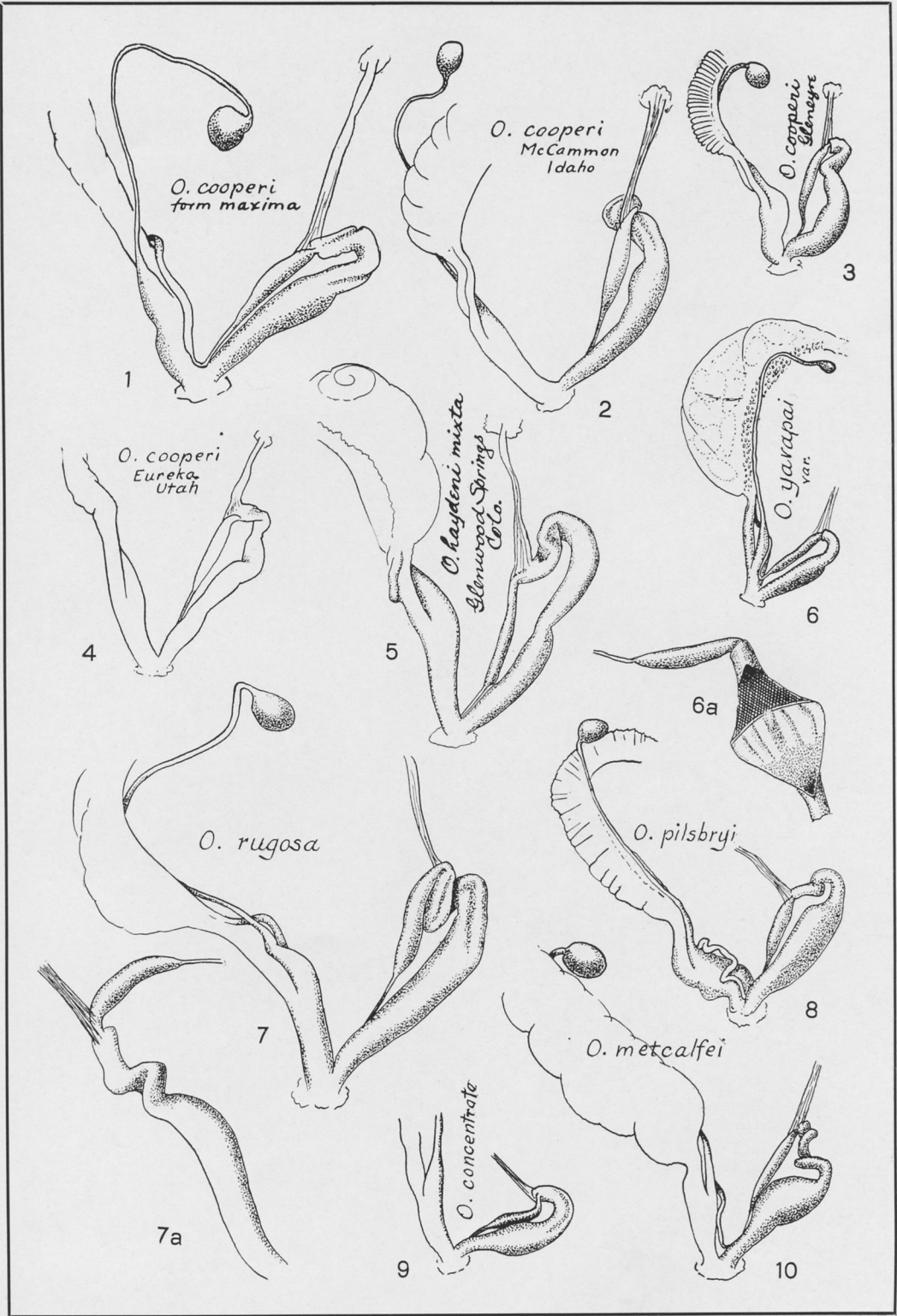


PILSBRY: ANATOMY OF OREOHELIX.



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